

IS BITCOIN THE NEW GOLD? THE TWO MAY BE MORE SIMILAR THAN YOU THINK, INCLUDING THEIR VALUE, USES, AND DELETERIOUS EFFECTS ON THE ENVIRONMENT

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I. INTRODUCTION

In the formative periods of America, the possibility of finding gold, silver, oil, and coal served as incentives for many to come to this country.¹ For many, the allure of possibly mining these resources was too great to resist.² In 1768, coal was found in Rhode Island, causing a massive influx of settlers; in 1849, a gold rush began after gold was discovered in California; and the same is true for oil when it was struck in 1859 by the Drake Well in Nevada.³ As author and historian Albert Sidney Bolles once stated:

The possibility of making a great deal of money in a short time always crazes people; and the discovery of large deposits of metal . . . affords just such inviting possibilities to the workman and to the capitalist. And . . . in the case of each of the great discoveries of lead, copper, gold, oil, and silver, a large proportion of the country's population has been rendered frantic.⁴

In the twenty-first century, like in the eighteenth and nineteenth centuries before, coal and gold have been found, and oil has been struck; but now, cryptos are the resource sought after by

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¹ Albert S. Bolles, *Mining History in the United States*, LEGENDS OF AMERICA, (Feb. 2020), <https://www.legendsofamerica.com/we-mininghistory/>.

² *Id.*

³ *Id.*

⁴ *Id.*

digital miners.⁵ Bitcoin is the new gold; Ethereum is the new coal; and Doge is the new oil. We have entered a new gold rush. This is the era of cryptocurrencies and the possibility of making a great deal of money has crazed people yet again and has caused large portions of the country to become fanatics.⁶

Such discoveries have always caused a mad rush of greed and excitement that led to many illogical decisions in pursuit of that greed and excitement.⁷ As it relates to the mineral and ore periods before, furnaces for smelting were built without regard for the fuel needed to run them, and ore blasting machines were ordered to locations without definitive information as to whether mineable ore existed in that location.⁸ These rash decisions were among “the ruinous mistakes . . . committed by frenzied speculators [that caused many great losses].”⁹ However, in the search for great wealth, there was an even greater loss to the environment caused by frenzied mineral speculators, and there may be a new type of frenzied speculator that is causing grave concern to the environment.¹⁰

The consequence of mining coal and silver was an enormous waste of other valuable resources.¹¹ In the silver mines of the Mississippi Valley, miners mostly mined galena, a lead sulfide mineral composed of about eighty-six percent lead and thirteen percent sulfur.¹² Galena, in rare situations, contained a small amount of silver, and often the lead was entirely wasted in the extraction of the small amount of silver.¹³ In the coal mines, only the highest quality of coal was kept, and lower qualities of coal were discarded or lost to caving.¹⁴ With silver mines, as soon as the most valuable

⁵ *Id.*

⁶ Epi Ludvik, *The “Cryptoboom” is the new gold rush*, MAIZE, (Jan. 15, 2018), <https://www.maize.io/magazine/the-cryptoboom-is-the-new-gold-rush/>.

⁷ *Id.*

⁸ *Id.*

⁹ *Id.*

¹⁰ *Id.*

¹¹ *Id.*

¹² *Id.*

¹³ Bolles, *supra* note 1.

¹⁴ *Id.*

silver was mined, the mines that contained other valuable and usable materials were nonetheless abandoned.¹⁵

The environmental effects of mineral mining are not localized to just the 1800 and 1900s. In 1848, after the Gold Rush, many mines were left open and abandoned in California.¹⁶ Mine tailings, the waste materials left after the target mineral was extracted from ores, were left exposed.¹⁷ Mine tailings often consist of crushed rock; processing chemicals like sulfuric acid and cyanide; and metals like copper, mercury, cadmium, and zinc.¹⁸ Rains mixed water with the mine tailings and created an amalgamation of toxic sludge that seeped into the groundwater.¹⁹ Since gold mining requires ample amounts of mercury, the toxic sludge that seeped into the groundwater contained deadly levels of mercury.²⁰

Geologists today estimate that nearly 7,600 tons of mercury made its way into just the rivers of the central Sierra Nevada in California.²¹ This contamination of water from excess mercury used in gold mining caused California to have the most acidic waters ever measured—scientists had to rely on negative PH to accurately measure the acidity of the water.²² This acid water killed local fish populations and poisoned the water supply.²³ Due to the contaminated water supply, the city of Redding, California has been forced to develop contingency plans for alternate sources of water.²⁴

¹⁵ *Id.*

¹⁶ Alex N. Helperin et al., California's Contaminated Groundwater, NATURAL RESOURCES DEFENSE COUNCIL, Apr. 2001, at 62.

¹⁷ *Tailings are Mine Waste*, EARTHWORKS, (2020), <https://earthworks.org/issues/tailings/>.

¹⁸ *Id.*

¹⁹ Helperin, *supra* note 16, at 64.

²⁰ *Id.* at 63.

²¹ *Id.*

²² *Id.* at 64.

²³ Michael J. McKinley, *Disasters: Environmental Mining Accidents*, POLLUTION ISSUES, <http://www.pollutionissues.com/Co-Ea/Disasters-Environmental-Mining-Accidents.html>.

²⁴ Helperin, *supra* note 16, at 64.

These effects of contamination and pollution are still being experienced today from actions that occurred over 150 years ago.²⁵

Cryptocurrencies are very similar to the precious metals that came before in more ways than just their value. A similar pattern of destructive and wasteful behaviors that accompanied gold, silver, and coal mining, now accompanies cryptomining and a major environmental catastrophe could be looming over us. To comprehend the environmental effects of cryptocurrency mining, blockchain technology must first be explored. The technology behind blockchain, the uses of blockchain, what makes it so popular, and how it allows cryptocurrencies to exist are important to understanding the environmental impacts of cryptomining as it relates to carbon dioxide emissions and electronic waste. Finally, to mitigate these environmental impacts, an amalgamation of government intervention, private sector innovation, and initiative on the individual level is required.

Once the basics of what a cryptocurrency is have been established, the requirements of cryptomining, and how cryptomining works can be explored. After cryptomining has been expanded upon, this Note will explore the issue of why cryptomining, like precious metal mining, has such a deleterious effect on the environment. The energy consumption and the electronic waste associated with cryptomining will also be discussed. Lastly, technological advancements and the governmental aspects of cryptomining will be expounded upon. What laws are currently in place to abate the environmental damage done by cryptomining? How have foreign countries legislated cryptocurrencies? What technological advancements have been made to address various environmental concerns? What actions? can individuals take to mitigate the problems associated with cryptocurrency mining? What should be done to ensure that cryptomining does not have the same disastrous effect on the environment as gold, silver, and coal mining?

²⁵ *Id.*

II. WHAT IS A BLOCKCHAIN?

This era has been called the “Cryptoboom” by some and the “Crypto Rush” by others^{26 27} While the nomenclature can be debated, the phenomenon is undisputed. This is the era of crypto, and it started in 2008 with a technology called blockchain.²⁸

The terms blockchain, cryptocurrency, and bitcoin are terms that are often used interchangeably but there are stark differences between them.²⁹ Bitcoin is a specific type of cryptocurrency that runs on blockchain technology.³⁰ It is impossible to understand blockchain without understanding bitcoin, and conversely, it is impossible to understand bitcoin without understanding blockchain. In the most rudimentary terms, blockchain is a digital public ledger that records all transactions.³¹ This digital ledger is able to be viewed by anyone and previous transactions cannot be changed or altered.³²

Each time a transaction occurs, the transaction is stored as a block.³³ If Person A has a mortgage payment of \$1,500.00 per month, and Person A pays his mortgage for January, that payment is recorded and stored as a block. If Person A then pays his \$1,500.00 mortgage for February, another block is created and connected to the first block from January’s transaction. Each block combines to create an irreversible chain of blocks or a blockchain.³⁴

²⁶ Ludvik, *supra* note 6.

²⁷ Andrew Charnings, *This isn’t the first time the world has sneered at Californian gold*. THE CRYPTO RUSH, (Mar. 15, 2018), <https://medium.com/blockchainedu/the-crypto-rush-1d12b91848cc>.

²⁸ Jorge Galavis, *Blame It On The Blockchain: Cryptocurrencies Boom Amidst Global Regulations*, 26 U. MIAMI INT’L & COMP. L. REV. 561 (2019) (controlling cryptocurrency).

²⁹ JOSEF L. CHEN, A BRIEF HISTORY OF CRYPTOCURRENCIES AND BLOCKCHAIN, 3 (2021).

³⁰ *Id.*

³¹ *Id.*

³² *Id.*

³³ *Id.* at 17.

³⁴ *Id.*

It is nearly impossible to dispute an earlier transaction because all transactions are visible to all users and cannot be edited.³⁵

Blockchain acts not only as a ledger for storing transactions, but it also boasts security in the form of encryption for all users and all devices.³⁶ A new user cannot access the network without being authenticated by the entire ledger. Blockchain's digital ledger technology that makes all transactions visible to all users, in a secure fashion, is the principal reason why blockchain is at the core of cryptocurrencies.³⁷

III. WHAT IS BITCOIN?

“Cryptocurrency, and the blockchain technology that makes it possible, is a societal revolution nothing short of Henry Ford's automobile, the printing press, or the Internet itself.”³⁸ This begs the question: what is a cryptocurrency? A cryptocurrency, as described by its creator, is “[a] purely peer-to-peer version of electronic cash [that] would allow online payment to be sent directly from one party to another without going through a financial institution,” but what does that actually mean?³⁹ The etymology behind the word cryptocurrency is a great starting point to truly understand what a cryptocurrency is and how they are truly revolutionary.

The word crypto comes from the practice known as cryptography.⁴⁰ Cryptography is the use of codes, symbols, and algorithms to keep information secret.⁴¹ Cryptography has been used for thousands of years in the realm of war and military conquest to pass encoded messages between units.⁴² One of the most famous uses of this form of cryptography was the German's use of *enigma*,

³⁵ *Id.*

³⁶ *Id.*

³⁷ *Id.* at 1.

³⁸ *Id.*

³⁹ *Id.* at 6.

⁴⁰ *Id.* at 3.

⁴¹ *Id.*

⁴² *Id.* at 1.

a cryptographic machine used to encode and hide messages from the allies, during World War II.⁴³

In modern times, cryptography is most associated with encrypting text messages or emails sent to one party to avoid the content of the message being intercepted by another party.⁴⁴ Cryptography relies on at least two sets of matching keys: one set is used by the system sending the information and the other by the system receiving the information.⁴⁵ Without both, the message is unreadable and usable.⁴⁶ The cryptography in cryptocurrency is used to secure online transactions—making transactions nearly impossible to fake.⁴⁷

While the idea of crypto may seem complex and convoluted, partially because there is no single orthodoxy understanding of what a cryptocurrency is, the idea of a currency is straightforward.⁴⁸ A currency is an item that acts as a representation of a value used to sell and buy other items.⁴⁹ A dollar, a yen, a yuan, and a peso are all forms of physical currencies that have been in existence for hundreds of years. However, the idea of merging cryptography with currency was first given life in 2008 when bitcoin was invented.⁵⁰

Satoshi Nakamoto, commonly believed to be a pseudonym for an anonymous person or group of people, registered the domain name bitcoin.org.⁵¹ This domain released bitcoin as an open-source code available for anyone to download.⁵² Bitcoin used cryptography to remove the centralized authority in transactions by making each

⁴³ David Mowry, *German Cipher Machines of World War II*, NATIONAL SECURITY AGENCY, 2014, at 15.

⁴⁴ Chen, *supra* note 29, at 5.

⁴⁵ *Id.*

⁴⁶ *Id.*

⁴⁷ *Id.*

⁴⁸ Elena Anatolyevna Kirillova ET AL., *Bitcoin, Lifecoin, Namecoin: The Legal Nature of Virtual Currency*, 9 J. ADVANCED RES. L. & ECON. 119 (2018) (discussing the introduction of licensing for mining).

⁴⁹ Chen, *supra* note 29, at 2.

⁵⁰ *Id.* at 4.

⁵¹ *Id.* at 5.

⁵² *Id.*

user of bitcoin responsible for the system security.⁵³ This concept of trading digital money between two parties without a third party, called peer-to-peer, works in part by forcing all users to verify all transactions before the transactions become official.⁵⁴ If person A wants to send person B ten bitcoins, the transaction is reported to all users of bitcoin and verified before the transaction is officially completed and recorded. Since there are no physical items transferring hands, the transaction exists solely online with each user there to verify the transaction.⁵⁵ The transaction stays pending until the transaction is confirmed by every user.⁵⁶ “Once it has been confirmed, it cannot be altered, which means there is zero risk of anyone ever trying to use the same funds twice for two different transactions.”⁵⁷

The most revolutionary concept of Nakamoto’s bitcoin invention was that it was the first decentralized digital cash system.⁵⁸ This meant that there was no centralized authority, like a bank, exercising control over transactions.⁵⁹ Many people distrust the idea of holding their money or assets in a bank or other financial institutions because those institutions are often influenced by governments.⁶⁰ “[P]urely peer-to-peer version of electronic cash [that] would allow online payment[s] to be sent directly from one party to another without going through a financial institution” makes more sense with an explanation of the term cryptocurrency and the history behind its inception.⁶¹ This definition of bitcoin, and all other cryptocurrencies, is found in the cryptocurrency’s whitepaper.⁶² Whitepapers serve two main functions for cryptocurrencies: to detail

⁵³ *Id.*

⁵⁴ *Id.* at 6.

⁵⁵ *Id.*

⁵⁶ *Id.*

⁵⁷ *Id.*

⁵⁸ *Id.*

⁵⁹ *Id.*

⁶⁰ *Id.*

⁶¹ *Id.*

⁶² *Id.*

the purpose of the cryptocurrency and to describe the technology used to achieve that purpose.⁶³

The second pertinent part of Nakamoto's definition of a cryptocurrency provides, "we propose a solution to the double-spending problem using a peer-to-peer network. The network timestamps transactions by hashing them into an ongoing chain of hash-based proof-of-work, forming a record that cannot be changed without redoing the proof-of-work."⁶⁴ This part of the definition of bitcoin set out to achieve the second goal of bitcoin, which was ensuring that the same funds were never used in a different duplicate transaction prior to the completion of the first transaction.⁶⁵

Not using duplicate funds is a simple concept to understand for physical and centralized items, but not so simple when you consider how digital funds work. If Person A wants to buy a specific vehicle and Person B is selling that specific vehicle, Person A can hand Person B physical money and person B can give Person A the vehicle. With this method, there is almost no risk of person A using funds that were already used, but using digital money is entirely different.

Digital money and items cannot be sent or given in the same way a nonphysical and non-centralized item can because when digital information is sent like in an email or a text message, what is really being sent is a copy of that email or text message.⁶⁶ The original copy of the email or text is not lost when sent because only a copy of that original is sent.⁶⁷ If Person A sends Person B digital money for the specific vehicle worth \$40,000.00, Person A could just copy, retain, and re-spend the digital money sent. This duplication of the digital money would make the digital \$40,000.00 worthless.

⁶³ *Whitepaper*, ALEXANDRIA, <https://coinmarketcap.com/alexandria/glossary/whitepaper>.

⁶⁴ Chen, *supra* note 29, at 7.

⁶⁵ *Id.*

⁶⁶ *Id.*

⁶⁷ *Id.*

When the desire to use digital cash first entered consumers' zeitgeist, centralized, third-party intermediaries, like PayPal and Visa ensured that when Person A sent money to Person B, that specific amount was debited from Person A's account and credited to Person B's account.⁶⁸ These third-party intermediaries, like Visa, profit from service fees and data processing revenue.⁶⁹ However, part of Nakamoto's vision for bitcoin was the elimination of personal data and fees collected by third-party intermediaries.⁷⁰

The solution of cryptology to prevent fraud without the use of third parties' payment processors is addressed by Nakamoto in the following portion of Nakamoto's Whitepaper on bitcoin.

What is needed is an electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party. Transactions that are computationally impractical to reverse would protect sellers from fraud, and routine escrow mechanisms could easily be implemented to protect buyers.⁷¹

Nakamoto then discusses digital signatures and hashes by stating, "[w]e define an electronic coin as a chain of digital signatures. Each owner transfers the coin to the next by digitally signing a hash of the previous transaction and the public key of the next owner and adding these to the end of the coin."⁷² The best analogy to this digital signature is registered mail. If Person A wants to ensure the delivery of an article of mail to Person D and

⁶⁸ *Id.* at 9.

⁶⁹ Nathan Reiff, *How Visa Makes Money*, INVESTOPEDIA, (Jan. 31, 2021), <https://www.investopedia.com/how-visa-makes-money-4799098#:~:text=Visa%20makes%20its%20profits%20by,the%20card%20Disui ng%20financial%20institution.>

⁷⁰ Chen, *supra* note 29, at 10.

⁷¹ *Id.*

⁷² *Id.*

wants to ensure the article of mail is not tampered with, Person A can send the article of mail via registered mail.⁷³

Registered mail provides extra protection and tracking for valuable mail with visible evidence of mailing and delivery at every phase.⁷⁴ Every article of registered mail has a specific tracking number matched to a specific piece of mail, and every time that piece of mail transfers possession, the individual receiving the piece of mail must sign.⁷⁵ Person A, the sender, delivers the mail to Person B, a mail courier. Person B must sign and prepare a log indicating that he has received this mail from Person A.⁷⁶ The mail is securely stored until Person B delivers it to another mail courier, Person C. When Person C delivers the article of mail to Person D, Person D can verify with the logs and signatures that this is the particular piece of mail that Person A sent. This concept of verification of ownership is a central concept in Nakamoto's vision for bitcoin. He stated that with bitcoin, "[a] payee can verify the signatures to verify the chain of ownership."⁷⁷

Because Nakamoto describes transferring a bitcoin by signing a hash, it is important to understand what a hash is, at least at a rudimentary level.⁷⁸ A hash is the output of a function that converts input data into an encrypted fixed-length output.⁷⁹ Hashes are central to blockchain and bitcoin because the hashes' outputs are the same if the inputs are the same, and the outputs cannot be reverse engineered to figure out the inputs.⁸⁰ It is similar to cooking a four-course meal. If a person eats your four-course meal, there is no way for a person to perfectly recreate your meal from eating it. There is no way for a person to deduce every single ingredient in

⁷³ UNITED STATES POSTAL SERVICE, <https://www.usps.gov/document/registered-mail> (last visited Mar. 27, 2022).

⁷⁴ *Id.*

⁷⁵ *Id.*

⁷⁶ *Id.*

⁷⁷ Chen, *supra* note 29, at 10.

⁷⁸ *Id.*

⁷⁹ Jake Frankenfield, *Hash*, INVESTOPEDIA (Jan. 13, 2022), <https://www.investopedia.com/terms/h/hash.asp>.

⁸⁰ *Id.*

every dish cooked, the amount of each ingredient used, the amount of time cooking, and when the ingredients were purchased. Adding just a single grain more of salt or buying a slightly bigger chicken breast just one minute later would all change the final meal. Although these changes may be imperceptible for cooking a dish, these changes would be monumental for a hash because the output is a series of letters and numbers.⁸¹

If you hashed a word like “Gold” as the input, the output, when run through a hashing function would create an output with the same length as if you hashed an entire sentence like “Bitcoin is the future.”⁸² “The function used to generate the hash is deterministic, meaning that it will produce the same result each time the same input is used.”⁸³ By looking at the output, the input is difficult, or nearly impossible, to determine.⁸⁴ A small change like “Golden” instead of “Gold” or “Bitcoins are the future” instead of “Bitcoin is the future” will produce an entirely different and unrecognizable output even though the changes to the input were minuscule.⁸⁵ This concept of hashing is critical to blockchain because it is used for the verification of transactions.⁸⁶

We need a way for the payee to know that the previous owners did not sign any earlier transactions. The only way to confirm the absence of a transaction is to be aware of all transactions . . . [t]he solution we propose begins with a timestamp server [that] works by taking a hash of a block of items to be timestamped and widely publishing the hash. To implement a distributed timestamp server on a peer-to-peer basis, we will need to use a proof-of-work system.⁸⁷

⁸¹ *Id.*

⁸² *Id.*

⁸³ *Id.*

⁸⁴ *Id.*

⁸⁵ *Id.*

⁸⁶ *Id.*

⁸⁷ Satoshi Nakamoto, *Bitcoin: A Peer-to-Peer Electronic Cash System*, (Oct. 31, 2008), <https://bitcoin.org/bitcoin.pdf>.

While there is a lot to unpack in this portion of Nakamoto's definition of bitcoin, most of this information is discussed earlier by Nakamoto.⁸⁸ It makes logical sense that the payee would want assurances that this same bitcoin was not spent earlier by the payor. Nakamoto states that the only way to ensure that this bitcoin was not spent earlier is to make all users aware of transactions.⁸⁹

As discussed earlier, a hash is the mathematical, fixed-length output created from specific data input.⁹⁰ Nakamoto proposed that the way to complete these peer-to-peer transactions, while preventing double spending, was to create a timestamp server by hashing timestamped data and publishing the hash output.⁹¹ Part of the data that is hashed is the block header.⁹²

The block header of a block includes the previous block hash, the bitcoin version number, the Merkle root, and the timestamp of the block among other information.⁹³ The bitcoin version number keeps track of any updates or changes to the protocol.⁹⁴ The Merkle root is a combination of all of the previous hashed transactions which itself is then hashed.⁹⁵ A timestamp, down to a fraction of a second, is included in the hash for the block header; thereby, allowing all to see a permanent encoded record of all events that occurred in the blockchain.

If any changes are made to the block, the change will be timestamped, and the outputted hash will be altered.⁹⁶ A changed hash makes it obvious to all others that a breach has occurred and the transaction with the changed hash will not be validated or published on the blockchain.⁹⁷ A transaction must be confirmed by

⁸⁸ *Id.*

⁸⁹ *Id.*

⁹⁰ Frankenfield, *supra* note 79.

⁹¹ Nakamoto, *supra* note 87.

⁹² Frankenfield, *supra* note 79.

⁹³ Jake Frankenfield, *Block Header (Cryptocurrency)*, INVESTOPEDIA, (Sept. 22, 2021), <https://www.investopedia.com/terms/b/block-header-cryptocurrency.asp>.

⁹⁴ *Id.*

⁹⁵ *Id.*

⁹⁶ Chen, *supra* note 29, at 11.

⁹⁷ *Id.* at 10.

everyone on the network before the transaction can be added to the blockchain.

The last hyper-technical concept for this section that is central to understanding bitcoin is proof-of-work, which is the crux of the environmental concerns surrounding bitcoin. Nakamoto stated, “to implement a distributed timestamp server on a peer-to-peer basis, we will need to use a proof-of-work system.”⁹⁸ Proof-of-work is a system that requires an enormous amount of effort, usually in the form of computational power, from the sender to verify entry into a network.⁹⁹ Proof-of-work is designed to deter spam, denial-of-service attacks, and other frivolous or malicious acts aimed to abuse the system or network.¹⁰⁰

If you owned a gym and you wanted to prevent nonmembers from loitering in your gym, you could position a guard at the entry of the gym and require all people requesting entry into the gym present proof of government ID, proof of gym membership, a fingerprint associated with the gym membership, and sign an affidavit each time he wanted to enter. It would require an enormous amount of effort to enter the gym because of all the proof required. This amount of work required to enter would deter people from entering simply to loiter.

“Proof-of-work [as it relates to crypto] is a decentralized consensus mechanism that requires members of a network to expend effort solving an arbitrary mathematical puzzle to prevent anybody from gaming the system.”¹⁰¹ This proof-of-work allows secure peer-to-peer transactions to occur with bitcoin and other cryptocurrencies.¹⁰² Absent a proofing method, all data stored on a network would be easily exposed and vulnerable to theft.¹⁰³ Also,

⁹⁸ Nakamoto, *supra* note 87.

⁹⁹ Jake Frankenfield, *Proof of Work (PoW)*, INVESTOPEDIA, (July 22, 2021), <https://www.investopedia.com/tech/whats-environmental-impact-cryptocurrency/>.

¹⁰⁰ *Id.*

¹⁰¹ *Id.*

¹⁰² *Id.*

¹⁰³ *Id.*

without a proving mechanism, there would be no way to verify or prove that the previous transactions were legitimate.¹⁰⁴ Proof-of-work makes exploiting a network too resource-intensive to be practical.¹⁰⁵ As it relates to bitcoin, the resource required for proof-of-work is computing power—which exponentially increases as more miners attempt to mine the cryptocurrency.¹⁰⁶

Proof-of-work is used in cryptocurrency mining, for validating transactions and mining new coins.¹⁰⁷ While cryptomining will be discussed in more detail below, cryptomining is a competitive computing process in which miners are rewarded with transaction fees and new coins for confirming transactions.¹⁰⁸

Nakamoto states, “[o]nce the CPU effort has been expended to make it satisfy the proof-of-work, the block cannot be changed without redoing the work. As later blocks are chained after it, the work to change the block would include redoing all the blocks after it.”¹⁰⁹ Nakamoto believed that proof-of-work made it extremely difficult to make changes in the block because changes in the blocks would require all blocks to be re-mined—which is labor-intensive and costly.¹¹⁰ Part of the input data for the hash of a block is a reference to the previous block; therefore, it is impossible to alter a previous block or transaction without altering every subsequent transaction and block.¹¹¹ Even if there is a change to a past transaction, the older the block, the more computing power it takes to change.¹¹²

Because blockchain is based on users validating transactions, it begs a central question: why would a person with no bitcoins expend the computing power to mine coins and validate transactions? The answer is money. More precisely, digital money

¹⁰⁴ *Id.*

¹⁰⁵ *Id.*

¹⁰⁶ *Id.*

¹⁰⁷ *Id.*

¹⁰⁸ *Id.*

¹⁰⁹ Nakamoto, *supra* note 87.

¹¹⁰ Frankenfield, *supra* note 99.

¹¹¹ Chen, *supra* note 29, at 13.

¹¹² *Id.*

or cryptocurrencies. In transactions involving third-party intermediaries, the third-party intermediary is incentivized to validate the transaction by taking a fractional cut of the amount being spent. Nakamoto knew that incentives needed to be baked into the DNA of blockchain for it to succeed. He stated,

[t]he first transaction in a block is a special transaction that starts a new coin owned by the creator of the block . . . and provides a way to initially distribute coins into circulation, since there is no central authority to issue them. The steady addition of a constant amount of new coins is analogous to gold miners expending resources to add gold to circulation. In our case, it is CPU time and electricity that is expended.¹¹³

Nakamoto stated perfectly how analogous cryptomining is to gold mining, and while he may have been drawing a parallel based solely on the mining of each asset, there is a parallel in the deleterious effect each has on the environment.¹¹⁴ In this instance, instead of using sulfuric acid, cyanide, and mercury to mine, Nakamoto suggested using compute time, compute power, and electricity.¹¹⁵ By offering the mere possibility of receiving bitcoins and transaction fees, Nakamoto is exploiting the same capitalistic inclination that Albert Sidney Bolle's observed concerning the craze and frenzy that cloaks individuals when the possibility of making a great deal of money in a short time is introduced.¹¹⁶ Instead of the possibility of striking gold by mining in California in 1859, there is a possibility that you can win bitcoin by mining on your computer at home in 2022.¹¹⁷ Your computer is your pick axe and electricity

¹¹³ Nakamoto, *supra* note 87.

¹¹⁴ *Bitcoin Energy Consumption Index*, DIGICONOMIST, (Feb. 2021), <https://digiconomist.net/bitcoin-energy-consumption>.

¹¹⁵ Nakamoto, *supra* note 87.

¹¹⁶ Bolles, *supra* note 1.

¹¹⁷ Jon Huang ET AL., *Bitcoin Uses More Electricity Than Many Countries. How Is That Possible?*, NEW YORK TIMES, (Sept. 3, 2021), <https://www.nytimes.com/interactive/2021/09/03/climate/bitcoin-carbon-footprint-electricity.html>.

is your sulfuric acid. The comparison of gold to bitcoin is apropos, and to further cement this point, the value of each can be compared.

It is impossible to quantify a standard measurement for an intangible asset like bitcoin, but, if you examine the standard masses each, in 2021, gold hit a high of \$61,335.91 for one kg¹¹⁸, while bitcoin hit a high of \$68,789.63 for one bitcoin in 2021.¹¹⁹

[Once the maximum number of coins have been created] [t]he incentive [to use electricity and CPU power] can also be funded with transaction fees The incentive may help encourage nodes to stay honest. If a greedy attacker is able to assemble more CPU power than all the honest nodes, he would have to choose between using it to defraud people by stealing back his payments, or using it to generate new coins. He ought to find it more profitable to play by the rules.¹²⁰

Nakamoto mentions that there is a finite amount of coins available to be mined, and once that number of coins is mined, miners are still incentivized by transaction fees to use computing power and electricity to validate transactions.¹²¹

Lastly, on top of cryptographic encryptions, hashes, timestamps, blocks, blockchains, and proof-of-work, Nakamoto envisioned one final salvo to ensure the integrity of bitcoin transactions: greed.¹²² If one bad actor could amass enough computing power to overcome all others on the network and re-mine a previous block, it would be more profitable to mine coins and

¹¹⁸ Calculating the All-time High Value In of 1 Kilogram in United States Dollars in 2021, GOLDPRICE, <https://goldprice.org/spot-gold.html> (In the scroll menus, choose “Gold,” “USD,” “KG,” and “1 Year” and view high values for the past year).

¹¹⁹ Calculating the All-time High Value for a bitcoin in United States Dollars in 2021, COINMARKETCAP, <https://coinmarketcap.com/Currencies/Bitcoin/Historical-Data/> (Click on “Historical Data,” change the date range to “Last 365 days,” and scroll to November 10, 2021).

¹²⁰ Nakamoto, *supra* note 87.

¹²¹ *Id.*

¹²² *Id.*

confirm transactions than to change previous transactions; therefore, he would be incentivized by his own greed not to undermine the system.¹²³

If you spent an hour explaining the intricate engineering behind a jet engine and explaining the aerodynamics behind the lift, drag, thrust, and weight of an airplane, that in it itself does not illustrate why people purchase plane tickets. However, explaining that you can use this technology to get from Miami to New York in under 3 hours does illustrate why people purchase plane tickets.¹²⁴ Similarly, explaining the esoteric and overly complicated concepts behind how blockchain and bitcoin work does not necessarily explain the mass appeal and frenzy behind blockchain and bitcoin; however, explaining the function and real-world applications of these technologies does.

IV. THE NEW GOLD FRENZY BEHIND BITCOIN AND BLOCKCHAIN

If you lived through the 2010s, it is almost impossible not to have witnessed the craze that surrounded investing in blockchain technologies like NFTs, bitcoin, and other cryptocurrencies. As a matter of fact, bitcoin was the best-performing asset from 2011 to 2021.¹²⁵ From 2011 to 2021, the cumulative return on bitcoin has dwarfed every other asset over the same time span with a gain of over 20,000,000 percent compared to the Nasdaq's gain of 541.3

¹²³ *Id.*

¹²⁴ Calculating the Time of a Flight from Miami to New York, FLIGHTSPHERE, <https://flightsphere.com/flight-time/from/miami/to/new-york/> (Click on "See All Cities," then click on "Miami," then click on "New York" to view the aver flight time).

¹²⁵ Samyuktha Sriram, *Bitcoin Becomes Best Performing Asset Of The Decade, Returning Ten Times More Than Nasdaq 100*, YAHOO, (Mar. 16, 2021) <https://www.yahoo.com/video/bitcoin-becomes-best-performing-asset-132208120.html#:~:text=Benzinga,Bitcoin%20Becomes%20Best%20Performing%20Asset%20Of%20The%20Decade%2C%20Returning,Times%20More%20Than%20Nasdaq%20100&text=After%20its%20recent%20surge%20to,of%2030%25%2C%20data%20shows.>

percent and gold's gain of 16.4 percent.¹²⁶ The prospect of outside investors, who are not involved in mining, gaining enormous returns on their investments has mass appeal, but the prospect of making money is not the only reason blockchain has been widely adopted.¹²⁷

Smart Contracts are digital contracts or programs that automatically activate, without human intervention, when there is consensus on the blockchain that certain conditions have been met.¹²⁸ Smart Contracts can be used to assist parties with real property transactions.¹²⁹ A mortgage can be integrated into a smart contract which could record and verify all payments automatically and release the property automatically when all payments have been made. Smart Contracts can also be used to hold the escrow in a contract for sale and purchase.¹³⁰ Funds can be automatically returned to the buyer if certain closing conditions are not met or applied to closing costs if certain conditions are met.¹³¹

Blockchain can be used in place of traditional online databases.¹³² Traditional databases work by replicating backups held on various servers and virtual machines.¹³³ When one copy is lost, the other copies are used to replace that lost copy.¹³⁴ While the main purpose of a traditional database is to manage data, while guaranteeing weak data consistency between the devices on the network, the main purpose of a blockchain database is to ensure data security while providing the strongest guarantee of data consistency across devices on the network.¹³⁵ These applications of blockchains

¹²⁶ *Id.*

¹²⁷ James Clavin, *Blockchains for Government: Use Cases and Challenges*, 1 DIGIT. GOV.: RES. PRACT. (Nov. 2, 2020).

¹²⁸ *Id.*

¹²⁹ Diego Geroni, *Top 12 Smart Contract Use Cases*, 101 BLOCKCHAINS, (Sept. 16, 2021), <https://101blockchains.com/smart-contract-use-cases/>.

¹³⁰ *Id.*

¹³¹ *Id.*

¹³² *Id.*

¹³³ *Id.*

¹³⁴ *Id.*

¹³⁵ *Id.*

are not merely theoretical, several governments have implemented these types of blockchains in their administrative functions.¹³⁶

Governments around the world have adopted blockchain technology for a variety of reasons.¹³⁷ In the United States, the Centers for Disease Control and Prevention (“CDC”) is using blockchain to help tract the outbreak of Hepatitis A.¹³⁸ José L. Arrieta, Chief Information Officer of the United States Health and Human Services (“HHS”) stated that HHS is using blockchain technology to track Covid-19 hospitalization.¹³⁹ Arrieta stated how this will “allow for faster clinical trials, protect citizens and flatten the curve on this pandemic, so we can recover from this pandemic using blockchain technology.”¹⁴⁰ Arrieta further stated, “[s]cience is about proving something and then sharing the steps of how you proved it. Creating timestamps in an immutable record [by using a blockchain] is truly empowering and allows for complete transparency from a data perspective.”¹⁴¹

Outside the United States, the Philippines adopted an Ethereum-based blockchain system for several banks to get access to financial services.¹⁴² Estonia has managed to convert ninety-eight percent of its tax system and ninety-nine percent of its healthcare data to a blockchain by implementing the e-Estonia program which uses e-identity, e-healthcare, and e-governance.¹⁴³ Sweden and Georgia have created blockchains for land registrations.¹⁴⁴ Malta, in an attempt to improve data safety and minimize bureaucracy,

¹³⁶ *Id.*

¹³⁷ James Clavin, *Blockchains for Government: Use Cases and Challenges*, 1 DIGIT. GOV.: RES. PRACT. (Nov. 2, 2020).

¹³⁸ *Id.*

¹³⁹ Jason Brett, *U.S. Health Department Chief Discloses Functioning Blockchain Project To Track Covid-19*, FORBES, (July 21, 2020), <https://www.forbes.com/sites/jasonbrett/2020/07/24/us-health-department-chief-discloses-functioning-blockchain-project-to-track-covid-19/?sh=29b32a021949>.

¹⁴⁰ *Id.*

¹⁴¹ *Id.*

¹⁴² Calvin, *supra* note 137.

¹⁴³ *Id.*

¹⁴⁴ *Id.*

created a national blockchain to store and manage academic documents such as diplomas and transcripts.¹⁴⁵

V. CRYPTO HESITANCY

While many people, companies, and countries have dove headfirst into the crypto environment, others have been very hesitant to do the same. Some aspects of the resistance to crypto are well founded, like the environmental concerns, but other aspects of crypto hesitancy are not well founded. Before diving into the legitimate causes for concern surrounding crypto, it would be more beneficial to first dispel the myths surrounding cryptocurrencies and blockchain.

Many believe that cryptocurrency is in a bubble market and that it's a fad that lacks any intrinsic value.¹⁴⁶ Investopedia defines a bubble market as an

[e]conomic cycle that is characterized by the rapid escalation of market value . . . [t]his fast inflation is followed by a quick decrease in value . . . sometimes referred to as a “crash” or a “bubble burst.” During a bubble, assets typically trade at a price, or within a price range, that greatly exceeds the asset's intrinsic value.¹⁴⁷

Cryptocurrencies are considered a fad just like the internet was considered a fad. Many experts have called crypto the gold of the digital age, stated its creation as the impetus of the fourth industrial revolution, and crypto is already the fifth most circulated currency in the world—despite having only been in circulation since 2009.¹⁴⁸ Many countries have also already implemented a version of blockchain into their governance structure.¹⁴⁹ Cryptocurrencies, and

¹⁴⁵ *Id.*

¹⁴⁶ Bolles, *supra* note 22-35.

¹⁴⁷ Will Kenton, *Bubble*, INVESTOPEDIA (Apr. 3, 2022), <https://www.investopedia.com/terms/b/bubble.asp>.

¹⁴⁸ *Id.* at 22.

¹⁴⁹ Calvin, *supra* note 137.

the blockchain technology that powers it, are already entrenched in many of our lives and they are here to stay.

The criticism that cryptocurrencies like bitcoin are intangible, are not backed by anything, and are therefore intrinsically valueless is an argument that is disingenuous at best. If you go to work, work, and then at the end of the pay period, your boss directly deposits your pay into your bank account, and you then use a portion of those funds to pay for a music streaming service, nothing in that scenario of events is tangible. Your proof of work is your pay which are intangible electronic funds deposited into your account. You may say “I can go to the bank and withdraw the value of my direct deposit in cash, so it is tangible.” Well, you can withdraw the value of your cryptocurrency in cash at most banks too.¹⁵⁰ Many of the largest banks and largest financial institutions allow funds for cryptocurrencies to be deposited or withdrawn.¹⁵¹ Bank of America, Chase, Citigroup, Citibank, Capital One, and Discover Bank all allow deposits and bank transfers for cryptocurrency purchases as long as credit is not used.¹⁵² USAA, Goldman Sachs, Simple Bank, and Ally all have some form of cryptocurrency functionality integrated into their banking interface.¹⁵³

One may still argue that even if many of the largest banks allow cryptocurrency transactions, cryptocurrencies are not backed by anything. The United States Dollar is a fiat currency which literally means it is not backed by anything other than trust in the government that issued it.¹⁵⁴ Conversely, cryptocurrencies are backed by the blockchain technology that powers them.¹⁵⁵ In the

¹⁵⁰ Banks Editorial Team, *Know Which Banks Accept Bitcoin, Get The Complete List*, BANKS.COM, (Feb. 11, 2022), <https://www.banks.com/articles/investing/cryptocurrency/banks-that-accept-bitcoin/>.

¹⁵¹ *Id.*

¹⁵² *Id.*

¹⁵³ *Id.*

¹⁵⁴ James Chen, *Fiat Money*, INVESTOPEDIA, (Oct. 26, 2021), <https://www.investopedia.com/terms/f/fiatmoney.asp>.

¹⁵⁵ Bolles, *supra* note 1.

above example about working, getting paid via direct deposit, and paying for a music streaming service, blockchain can power all three of those transactions.

A smart contract on a blockchain can be set up to record all of your logged hours for work and automatically initiate a direct deposit on a specific date. Your bank can set up a private blockchain database to securely store and manage transactions for all accounts. Lastly, the music streaming platform can set up a blockchain and a smart contract to securely manage and store all the financial information of the subscribers and automatically charge subscribers when certain conditions are met. A blockchain could even be used to store and catalog all of the music of the streaming company. Coupled with the fact that there are only a limited and finite number of bitcoins that can be in circulation, bitcoin and blockchain undoubtedly have intrinsic value. With the limitless applications of blockchains and cryptocurrencies, stating they have no intrinsic value is akin to stating electricity has no intrinsic value.

While there are certainly many more illegitimate criticisms of blockchain and bitcoin that can be easily refuted, like the widescale usage in criminal enterprises, for example, there are certainly legitimate criticism and cause for concern with respect to energy consumption and electronic waste that are associated with cryptocurrency mining.

VI. THE EFFECTS OF BITCOIN ON THE ENVIRONMENT

Cryptomining is the process of issuing new coins into circulation and validating transactions using a computational mathematical process.¹⁵⁶ Cryptomining is required to add new transaction records to the coins' blockchain.¹⁵⁷ To prevent fraudulent transactions from being validated and added to the blockchain, mining needs to be costly for individuals. Nakamoto

¹⁵⁶ Ed Howden, *The Crypto-Currency Conundrum: Regulating an Uncertain Future*, 29 EMORY INT'L L. REV. 741, 748 (2015) (Governments Are Taking Different Stands on Regulating Crypto-Currencies).

¹⁵⁷ *Id.* at 747-748.

“intentionally designed the mining process to be resource intensive.”¹⁵⁸ Compute or computational power is the resource used by the miner to participate in cryptomining.¹⁵⁹ By design, bitcoin mining wastes electricity by turning electricity into security.¹⁶⁰

In 2009, a person could mine a bitcoin with a basic home computer for just a few seconds worth of electricity.¹⁶¹ Now, an entire server room is required, comprised of multiple computers, using several years’ worth of electricity, is required to mine a single bitcoin.¹⁶² To put this consumption difference into perspective, originally, it cost less than a penny’s worth of electricity to mine a single bitcoin.¹⁶³ Now, it costs around nine years of electricity, or about \$12,500.00, to mine a single bitcoin.¹⁶⁴

Mining bitcoins annually consumes around “91 terawatt-hours of electricity, more than is used by Finland, a nation of about 5.5 million.”¹⁶⁵ This energy consumption for bitcoin mining has increased tenfold in the last five years and now represents half of a percent of all the electricity used on earth.¹⁶⁶

¹⁵⁸ *Id.* at 748.

¹⁵⁹ *Id.* at 749.

¹⁶⁰ Huang, *supra* note 117.

¹⁶¹ *Id.*

¹⁶² *Id.*

¹⁶³ Jon Huang, Claire O’Neill, and Hiroko Tabuchi, *Bitcoin Uses More Electricity Than Many Countries. How Is That Possible?*, NEW YORK TIMES, (Sept. 3, 2021), <https://www.nytimes.com/interactive/2021/09/03/climate/bitcoin-carbon-footprint-electricity.html>.

¹⁶⁴ Jon Huang, Claire O’Neill, and Hiroko Tabuchi, *Bitcoin Uses More Electricity Than Many Countries. How Is That Possible?*, NEW YORK TIMES, (Sept. 3, 2021), <https://www.nytimes.com/interactive/2021/09/03/climate/bitcoin-carbon-footprint-electricity.html>.

¹⁶⁵ Huang, *supra* note 116.

¹⁶⁶ *Id.*

Most bitcoin mining facilities are situated in regions where electricity is primarily coal-based.¹⁶⁷ Coal burning increases greenhouse gas emissions in the form of carbon dioxide emissions which contribute greatly to climate change.¹⁶⁸ The Environmental Protection Agency (the “EPA”) conducted a study on the contribution of greenhouse gas emissions to climate change, and on December 15, 2009, the Administrator of the EPA stated that “the combined emissions of these greenhouse gases . . . contribute to the greenhouse gas air pollution that endangers public health and welfare” of current and future generations.¹⁶⁹

The adverse effects of greenhouse gas emissions ranged from sea level rise to increases in food and water-borne pathogens.¹⁷⁰ “Given this Endangerment Finding, the EPA’s legislative mandate required the agency to regulate greenhouse gas emissions.”¹⁷¹

“Estimates vary, but some research suggests that the amount of electricity consumed by cryptocurrency per year now exceeds the annual energy consumption (and carbon emissions) of many countries.”¹⁷² The most recent studies done by Digiconomist estimate that over 200 terawatt-hours of electricity annually are used by bitcoin, which creates about 100 megatons of carbon dioxide emissions¹⁷³ This is equivalent to over 100,000,000,000 pounds of burning coal or the entire carbon footprint of Kuwait per year.¹⁷⁴ A study done by Nature Climate Change found that bitcoin emissions, at their current rate, could create an electricity demand capable of

¹⁶⁷ Gregory Barber, *Bitcoin’s Climate Impact Is Global. The Cures Are Local*, Wired (June 12, 2019, 11:00 AM) <https://www.wired.com/story/bitcoins-climate-impact-global-cures-local/>.

¹⁶⁸ *Id.*

¹⁶⁹ Caroline Cecot, *Blowing Hot Air: An Analysis of State Involvement in Greenhouse Gas Litigation*, 65 VAND. L. REV. 189 (2012).

¹⁷⁰ *Id.*

¹⁷¹ *Id.*

¹⁷² Kevin V. Tu, *Crypto-Collateral*, 21 SMU SCI. & TECH. L. REV. 205, 252 (2018) (discussing the regulations of cryptocurrencies and energy consumption).

¹⁷³ Bitcoin Energy Consumption Index, *supra* note 114.

¹⁷⁴ *Id.*

producing enough emissions to increase global temperatures 2°C in the next few decades.¹⁷⁵

A 2021 report from the University of Cambridge found that thirty-five percent of bitcoin mining takes place in the United States, and about eighteen percent of bitcoin mining takes place in Kazakhstan, and both countries are primarily reliant on fossil fuels for energy.¹⁷⁶

Many users of bitcoin are simply using the coin for transactions and not bitcoin mining but comparatively, these bitcoin transactions are no less environmentally harmful than actual mining.¹⁷⁷ A single peer-to-peer bitcoin transaction has the equivalent carbon footprint of 2,334,954 VISA transactions, the power consumption to power an average home for seventy-six days, and produces electronic waste comparable to two iPhone 12s.¹⁷⁸

Bitcoin's environmental impact is not solely limited to an energy consumption problem, there is also an electronic waste problem.¹⁷⁹ Bitcoin mining was initially done using the central processing units, but then it was found to be more efficient to use graphic processing units ("GPU") and application-specific integrated circuits ("ASIC") for mining Bitcoins.¹⁸⁰

According to Koomey's law, "the electrical efficiency of computing (the number of computations that can be completed per kilowatt-hour of electricity) . . . double[s] about every 1.5 years."¹⁸¹ Due to the advancements in mining technology, mining equipment becomes obsolete every 1.5 years because, with electricity costs and

¹⁷⁵ Camilo Mora et al., *Bitcoin emissions alone could push global warming above 2°C*, NATURE CLIMATE CHANGE 8, 931-36 (Nov. 2018), <https://www.nature.com/articles/s41558-018-0321-8.epdf>.

¹⁷⁶ Nathan Reiff, *What's the Environmental Impact of Cryptocurrency?*, INVESTOPEDIA, (Dec. 21, 2021), <https://www.investopedia.com/tech/whats-environmental-impact-cryptocurrency/>.

¹⁷⁷ Bitcoin Energy Consumption Index, *supra* note 112.

¹⁷⁸ *Id.*

¹⁷⁹ *Bitcoin Electronic Waste Monitor*, DIGICONOMIST, (Feb. 13, 2021), <https://digiconomist.net/bitcoin-electronic-waste-monitor/>.

¹⁸⁰ *Id.*

¹⁸¹ *Id.*

compute power, only the most cost-efficient mining machines can remain economically viable.¹⁸² Many mining machines, especially ASIC mining machines, are discarded after they become obsolete because they are single-purpose machines. Over 35 kilotons of electronic waste are produced from bitcoin mining each year.¹⁸³ It is important to keep in mind that all of the above-mentioned data about the environmental harm relates only to bitcoin—as of May 2021, there are over 15,000 other cryptocurrencies in circulation.¹⁸⁴

Cryptomining is not just having an impact on the future climate, the effects can be felt by people now.¹⁸⁵ In Washington, cryptomining activities have stressed the power grids to the point of causing transformers to overheat.¹⁸⁶ These mining activities have increased electricity costs and even caused blackouts.¹⁸⁷ The capital city of Iran, Tehran, along with several other cities, has faced power outages partly because of bitcoin mining.¹⁸⁸ Kazakhstan, the world's second-largest miner of Bitcoin, temporarily banned all cryptomining because of power outages alleged to be caused by cryptomining.¹⁸⁹

¹⁸² *Id.*

¹⁸³ *Id.*

¹⁸⁴ Reiff, *supra* note 176.

¹⁸⁵ Tu, *supra* note 172, at 50.

¹⁸⁶ *Id.*

¹⁸⁷ Natasha Truak, *Iran Bans Bitcoin Mining as Its Cities Suffer Blackouts and Power Shortages*, CNBC (May 26, 2021, 2:27 PM)

<https://www.cnbc.com/2021/05/26/iran-bans-bitcoin-mining-as-its-cities-suffer-blackouts.html>.

¹⁸⁸ *Id.*

¹⁸⁹ Elmira Tanatarova, *Bitcoin mining centres are shut down in Kazakhstan as authorities blame crypto miners for electricity shortages in world's second-biggest data mining hotspot*, DAILYMAIL, (Jan. 29, 2022),

<https://www.dailymail.co.uk/news/article-10454811/Bitcoin-mining-centres-shut-Kazakhstan-authorities-blame-crypto-miners-outages.html>.

VII. SOLUTIONS TO ENVIRONMENTAL PROBLEMS CRYPTOCURRENCIES

The applications of blockchain are limitless, but without government intervention and structural changes to how cryptomining works, there will be catastrophic damage done to the environment. There is no way to avoid the massive amounts of carbon dioxide emissions and electronic waste from cryptocurrencies without the technology behind the blockchains changing. To mitigate the harm to the environment caused by cryptocurrencies, a two-pronged attack is needed: 1) cryptomining itself needs to be more energy efficient, and 2) there needs to be government intervention in the form of renewable energy incentives and taxes to minimize the effect of cryptocurrencies on the environment.

Ethereum, another major cryptocurrency, is transitioning from proof-of-work to proof-of-stake.¹⁹⁰ Similar to proof-of-work, proof-of-stake is a consensus-based method for confirming transactions and adding new blocks to the blockchain.¹⁹¹ Proof-of-stake reduces the amount of energy and computational work required to verify a transaction.¹⁹² Ethereum owners can offer up their Ethereum coins as collateral, known as “staking,” for a chance to validate blocks and mine.¹⁹³ Once an Ethereum coin owner stakes a specific number of coins, he becomes a validator or a person who can validate transactions.¹⁹⁴ Rather than using an energy-based competition like proof-of-work, validators are randomly selected to mine and validate blocks.¹⁹⁵ Once a specific number of validators validates a transaction, the transaction becomes part of the block.¹⁹⁶

¹⁹⁰ *Proof-of-Stake (PoS)*, (Jan. 26, 2022), ETHEREUM, <https://ethereum.org/en/developers/docs/consensus-mechanisms/pos/>.

¹⁹¹ Jake Frankenfield, *Proof-of-Stake (PoS)*, INVESTOPEDIA, (Dec. 17, 2021), <https://www.investopedia.com/terms/p/proof-stake-pos.asp>.

¹⁹² *Id.*

¹⁹³ *Id.*

¹⁹⁴ *Id.*

¹⁹⁵ *Id.*

¹⁹⁶ *Id.*

Since proof-of-work electricity costs are paid with a fiat currency, proof-of-work-based coins are trading less valuable electricity for more valuable coins.¹⁹⁷ Proof-of-stake is specifically designed to address the scalability and environmental concerns of proof-of-work by substituting staking for computational power.¹⁹⁸ Since the validators are chosen at random, there is a massive reduction in energy cost when compared with the competition associated with proof-of-work.¹⁹⁹

Proof-of-stake also boasts a security feature absent in proof-of-work systems.²⁰⁰ Proof-of-work systems, although unlikely, are susceptible to 51% of attacks.²⁰¹ This 51% of attacks occur when a single entity amasses 51% of the computational power and electricity and can then re-mine and validate fraudulent transactions. Since the validators in proof-of-stake systems are randomly chosen, an entity with 51% of the coins will not necessarily have the sole power to validate transactions.²⁰² Also, validators lose all coins staked if they attempt to validate a fraudulent transaction.²⁰³

With enhanced security and reduced overhead electrical costs, there are inherent incentives for other cryptocurrencies and blockchains to migrate away from proof-of-work to proof-of-stake. Other cryptocurrencies like Peercoin, Nxt, Blackcoin, and ShadowCoin have already adopted proof-of-stake, and many more should.²⁰⁴ As proof-of-stake-based cryptocurrencies become more widely implemented in place of proof-of-work-based cryptocurrencies, carbon dioxide emissions will be mitigated due to the absence of the electricity requirements of proof-of-work.²⁰⁵ Cryptocurrencies must adopt a more energy-efficient system like proof-of-stake to reduce environmental concerns associated with

¹⁹⁷ *Id.*

¹⁹⁸ *Id.*

¹⁹⁹ *Id.*

²⁰⁰ *Id.*

²⁰¹ *Id.*

²⁰² *Id.*

²⁰³ *Id.*

²⁰⁴ *Id.*

²⁰⁵ *Id.*

cryptocurrencies. On March 14, 2022, the European Union's held a vote to ban proof-of-work and force those cryptocurrencies to move over to a more environmentally sustainable method of verification.²⁰⁶ While the vote ultimately failed in a thirty to twenty-two decision, this vote shows that governments are attempting to take steps to limit the negative environmental impacts of crypto mining.²⁰⁷

VIII. GOVERNMENT ACTION

In 2021, China took a great leap and decided to ban all cryptomining in China.²⁰⁸ One reason Chinese officials cited for the ban was the environmental concerns associated with cryptomining.²⁰⁹ Meng Wei, a spokesperson for China's National Development and Reform Commission, stated, “[v]irtual currency mining features high energy consumption and carbon emissions, and doesn’t play a positive role in industrial development and technological progress . . . [Crypto's] blind and disorderly development have a severe adverse impact on promoting high-quality economic and social development, energy conservation, and emission reduction.”²¹⁰ China went from mining two-thirds of all bitcoins on earth in April 2021 to not mining any bitcoin as of July 2021.²¹¹

China is not the country that has taken such a drastic step to regulate cryptocurrencies; Egypt, Iraq, Qatar, Oman, Morocco,

²⁰⁶ Sandali Handagama, *Proposal Limiting Proof-of-Work Is Rejected in EU Parliament Committee Vote*, COINDESK, (Mar. 14, 2022), <https://www.coindesk.com/policy/2022/03/14/proposal-limiting-proof-of-work-is-rejected-in-eu-parliament-committee-vote-sources/>.

²⁰⁷ *Id.*

²⁰⁸ Grady McGregor, *China already banned crypto mining. Now it's cracking down on any holdouts*, FORTUNE, (Nov. 17, 2021) <https://fortune.com/2021/11/17/china-bitcoin-mining-ban-crypto-holdouts-ether-solana-price/>

²⁰⁹ *Id.*

²¹⁰ *Id.*

²¹¹ *Id.*

Algeria, Tunisia, Bangladesh, and China have all banned cryptocurrency.²¹² Forty-two other countries have in effect banned cryptocurrencies by restricting banks from allowing transactions with cryptocurrencies or prohibiting cryptocurrency exchanges.²¹³

Are such draconian measures needed to mitigate the harmful effects of cryptocurrencies? The short answer is *no*. In *Massachusetts v. EPA*, the Court determined that carbon dioxide emissions are clearly a “substance . . . which is emitted into . . . the ambient air” and therefore, the EPA has authority to regulate it.²¹⁴ This means that the EPA has the legislative authority to regulate carbon dioxide emissions generated as a result of cryptomining. Instead of using governmental legislative authority to ban blockchains and cryptomining, why not use crypto?

Because of the sheer amount of electronic waste created by bitcoin, renewable energy solutions alone can never solve bitcoins sustainability problems.²¹⁵ Mitigating the electronic waste from cryptomining makes for an important issue that also must be addressed because “only 20% of all electronic waste is recycled, the rest makes its way to environmentally damaging and dangerous landfills.”²¹⁶ There are two steps that must be taken to mitigate the problem of electronic waste: 1) companies who manufacture items that are used by crypto miners, must manufacture products that are more environmentally conscionable, and 2) crypto miners must make more efforts to recycle obsolete components, if not by choice, then by law.

Nvidia, one of the largest producers of GPUs, has begun segregating its production of its GPUs used for gaming and video editing from the GPUs that are used for cryptomining.²¹⁷ For the

²¹² *Regulation of Cryptocurrency Around the World: November 2021 Update*, LAW LIBRARY OF CONGRESS, (Nov. 2021), <https://tile.loc.gov/storage-services/service/l1/l1glrd/2021687419/2021687419.pdf>.

²¹³ *Id.*

²¹⁴ *Massachusetts v. EPA*, 549 U.S. 497 (2007).

²¹⁵ Bitcoin Electronic Waste Monitor, *supra* note 179.

²¹⁶ *Id.*

²¹⁷ Nicholas Pongratz, *Nvidia Creating Crypto Specific Graphics Card to Avoid Boom-and-Bust*, YAHOO, (June 22, 2021), <https://www.yahoo.com/video/nvidia->

gaming GPU, Nvidia purposely limited hash rates to make the more inefficient for mining while it introduced crypto-mining processors (“CMPs”) designed specifically for mining. Because CMPs are less complicated than traditional GPUs, parts that would otherwise be discarded as unfit for making GPUs are used for producing CMPs.²¹⁸ This process allows Nvidia to produce more efficient components.

Scientists at 3M worked to lower the amount of energy needed for cryptomining by utilizing immersion cooling fluids to cool data centers.²¹⁹ As discussed previously, cryptomining requires a massive amount of energy, and massive amounts of heat are produced from the energy used by the mining machines.²²⁰ To keep the cryptomining machines functioning, the crypto machines must be air-conditioned.²²¹ Much of the energy costs of cryptomining are attributed to the cooling of the cryptomining machines.²²² A new process known as “open-bath immersion cooling” or “passive two-phase immersion cooling,” could help to reduce the electricity consumption of cryptomining.²²³

Passive two-phase immersion cooling “happens in vessels that are maintained at atmospheric pressure using control systems . . . Because the systems are maintained at atmospheric pressure, they are able to be opened at any time for servicing, allowing you to

creating-crypto-specific-graphics-141844544.html#:~:text=Graphics%20card%20producer%20Nvidia%20is,and%20the%20RTX%203070%20Ti.

²¹⁸ *Id.*

²¹⁹ Kelly Hall, *Exploring solutions to the surprising energy consumption of Bitcoin mining*, 3M, (Feb. 10, 2022), https://www.3m.com/3M/en_US/particles/all-articles/article-detail/~/bitcoin-mining-energy-consumption-immersion-cooling-sustainable-solution/?storyid=99578928-1e76-42dd-867b-e888a9f07bf0

²²⁰ *Id.*

²²¹ *Id.*

²²² *Id.*

²²³ *Id.*

remove one server while other servers remain operational and able to continue boiling.”²²⁴

Allied Control created their company in Hong Kong with the purpose of mining for bitcoin.²²⁵ The size and the number of air conditioners needed to cool the cryptomining machines became impractical.²²⁶ With 3M’s help, Allied Control built a passive two-phase immersion cooling data center for cryptomining.²²⁷ By switching to the passive two-phase immersion cooling approach, the critical load of Allied Control’s Crypto machines increase from seventy kilowatts to 500 kilowatts, and, at the same time, the amount of power Allied Control required to crypto mine decreased drastically.²²⁸

No matter how efficient cryptomining machines are, there will still eventually be the need to replace parts. One action crypto miners can take is to reduce the impacts of cryptomining is recycling.²²⁹ Companies, like Bitnand Mining, “recycle your miner to ensure the components are reused, recycled, or disposed of in an environmentally responsible manner. Many parts in your crypto miner can be recycled to reduce electronics waste.” Bitnand Mining recycles ASICs, GPUs, and Power supply units.²³⁰ To mitigate the effects cryptomining has on the environment and avoid climate disasters and power shortages, widespread and robust action must be taken. Crypto miners must transition to using more renewable forms of energy to mine, either by carrot or by stick. Blockchains and cryptocurrencies must transition to a more power-efficient

²²⁴ *Id.*

²²⁵ *Id.*

²²⁶ *Id.*

²²⁷ *Id.*

²²⁸ *Id.*

²²⁹ Miner Recycling Program, BITNAND MINING, (Feb. 15, 2022), <https://www.bitnand.com/miner-recycling-program#:~:text=Many%20parts%20in%20your%20crypto,recycled%20to%20reduce%20electronics%20waste.&text=Our%20global%20miner%20recycling%20program,ASIC%20miners>

²³⁰ *Id.*

method of verifying transactions like proof-of-stake.²³¹ Companies that manufacture equipment needed for mining must make concerted efforts to make those products and processes more efficient and crypto miners, themselves, must take a proactive step to ensure their electronic waste is being recycled properly.

IX. CONCLUSION

To sum up what bitcoin is, it is a digital currency distributed and recorded on a digital ledger called a blockchain.²³² The blockchain acts as a safety feature to prevent instances of double-spending by recording the details of all transactions and arranging the transaction details into publicly viewable blocks.²³³ To prevent modifications of previous transactions, the data from blocks are hashed.²³⁴ Hashing is a mathematical function that encrypts data and outputs a standard-length hash.²³⁵ The data for a hash only moves one way; therefore, a hash cannot be used to obtain the original data.²³⁶ The hash can only be used to match the original data and matching the hash serves as proof-of-work.²³⁷ The proof-of-work, in the form of computing power and electricity, increases proportionally to the miners on the network.²³⁸ Proof-of-work is used to verify or match the hashes and to mine new coins for circulation.²³⁹

There is no way to overstate the possibilities of blockchain or the value of bitcoin. With where blockchain can take us, it is not conjectured to say that it is this era's version of the steam engine or spaceship. Similarly, with the valuation of bitcoin and the mass hysteria surrounding its mining, bitcoin is undoubtedly this era's

²³¹ Frankenfield, *supra* note 191.

²³² *Id.*

²³³ *Id.*

²³⁴ *Id.*

²³⁵ *Id.*

²³⁶ Frankenfield, *supra* note 99.

²³⁷ *Id.*

²³⁸ *Id.*

²³⁹ *Id.*

gold. And just like with all other previous valuable innovations and discoveries, the urge to make profits blinds many to any associated dangers. Blockchain and bitcoin are no different.

Although bitcoin is a revolutionary way to spend money and transact business, there is a massive environmental cost to using this technology. The energy consumption required to mine bitcoin and validate transactions is problematic as it relates to the carbon dioxide emissions and environmental effects are not solely contained to carbon emissions. Bitcoin mining also creates an astronomical amount of physical electronic waste. To fix these environmental problems, governments, corporations, and individual miners must all work together. Governmental bodies, with taxes or incentives, must steer crypto miners to mine using more renewable sources of energy, cryptocurrencies and blockchains must shift to less resource-intensive means of validating transactions like proof-of-stake, and private companies must create and manufacture more energy-efficient technology to assist bitcoin and blockchain to the energy consumption, and individual miners must make a substantial effort to recycle their obsolete components.

Blockchain and bitcoin are too valuable to lose; therefore, changes like these must be made to ensure these technologies are viable and sustainable for the future.